Improved analysis on $\gamma\gamma \to$ *higgs* $\to b\bar{b}$

for SM and MSSM,

with overlaying events,

vertex smearing and crab crossing

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Overview

Analysis of $\sigma(\gamma\gamma \to \textit{higgs} \to b\bar{b})$ measurement
Montpellier:

- realistic $\gamma\gamma$-spectra
- b-tagging
- overlaying events $\gamma\gamma \to$ *hadrons* (OE)

$\Rightarrow$ results for SM at $M_h = 120, 130, 140, 150, 160$ GeV

$\Rightarrow$ results for MSSM at $M_A = 200, 250, 300, 350$ GeV
with $\tan\beta = 7$, $M_2 = \mu = 200$ GeV (following M. Mühlleitner *et al.*)

NEW:

- improved treatment of overlaying events
- crossing angle
- primary vertex distribution
- $\gamma\gamma \to W^+W^-$ background contribution

$\gamma\gamma \to \boldsymbol{higgs} \to b\bar{b}$

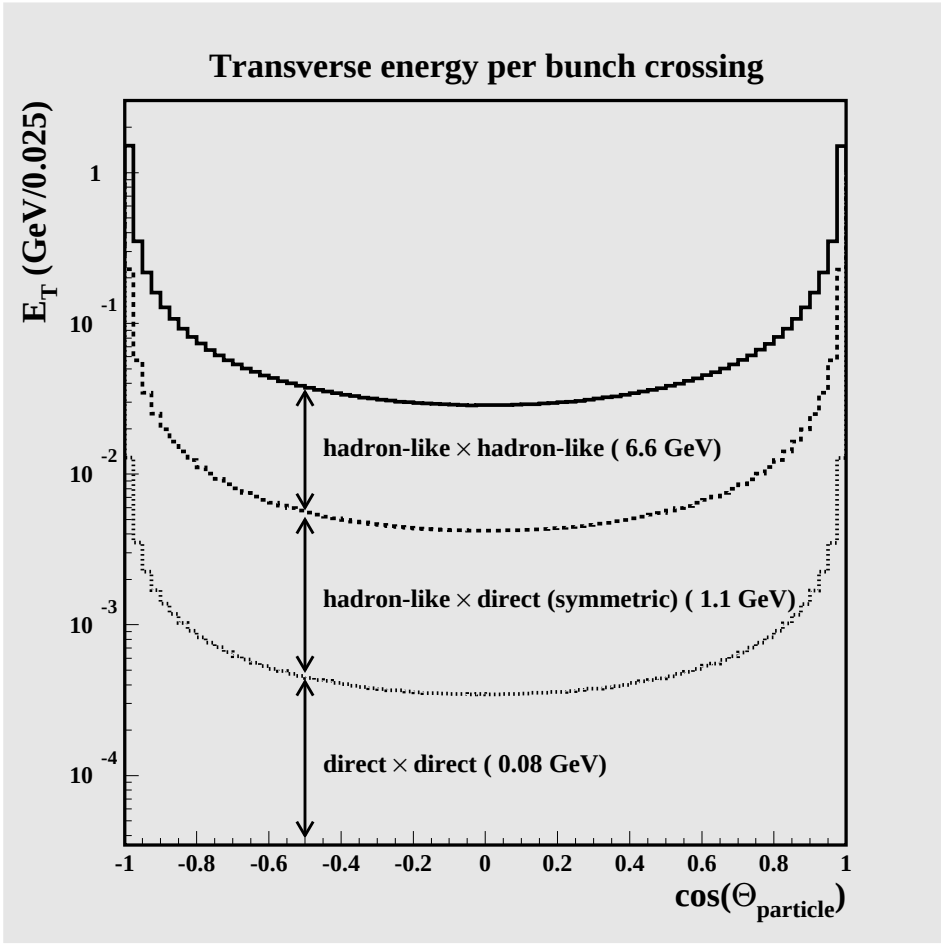
Photon-photon spectrum: CompAZ
Signal: HDECAY, PYTHIA
Background: NLO $Q\bar{Q}(g)$ (G. Jikia); $\gamma\gamma \to W^+W^-$ (PYTHIA)
Pile-up events $\gamma\gamma \to$ *hadrons* (PYTHIA) with realistic $\gamma\gamma$-luminosity spectrum (V. Telnov)
Parton Shower (signal & $\gamma\gamma \to W^+W^-$): PYTHIA
Fragmentation: PYTHIA (Lund)
Detector performance: SIMDET 4.01
Jets: Durham algorithm, $y_{cut} = 0.02$ (clusters & tracks with $|\cos\theta| > \cos\theta_{\text{det}} = 0.85$ ignored)

Selection of $b\bar{b}$ events for $M_{higgs} = 120$ (300) GeV:

- OE-jets suppression: consider only jets with $p_T^{\text{jet}}/E_T > 0.1$
- $N_{\text{jets}} =$ 2, 3 (2)
- $|\cos\theta_{\text{jet}}| < 0.71$ (0.65) for each jet
- $|P_z|/E < 0.12$ (0.07) where $P_z = \sum p_z^{\text{jet}}$ and $E = \sum E^{\text{jet}}$
- To suppress $\gamma\gamma \to W^+W^-$ background, for $M_{higgs} >$ 160 GeV (MSSM): $P_T/E_T < 0.11$ & $M_{\text{jet1}} <$ 70 GeV & $M_{\text{jet2}} <$ 50 GeV; at least 7 tracks in each jet
- ZVTOP-B-Hadron-Tagger by T. Kuhl
- Correction for crossing angle: boost with $\beta = \sin(\alpha_c/2)$

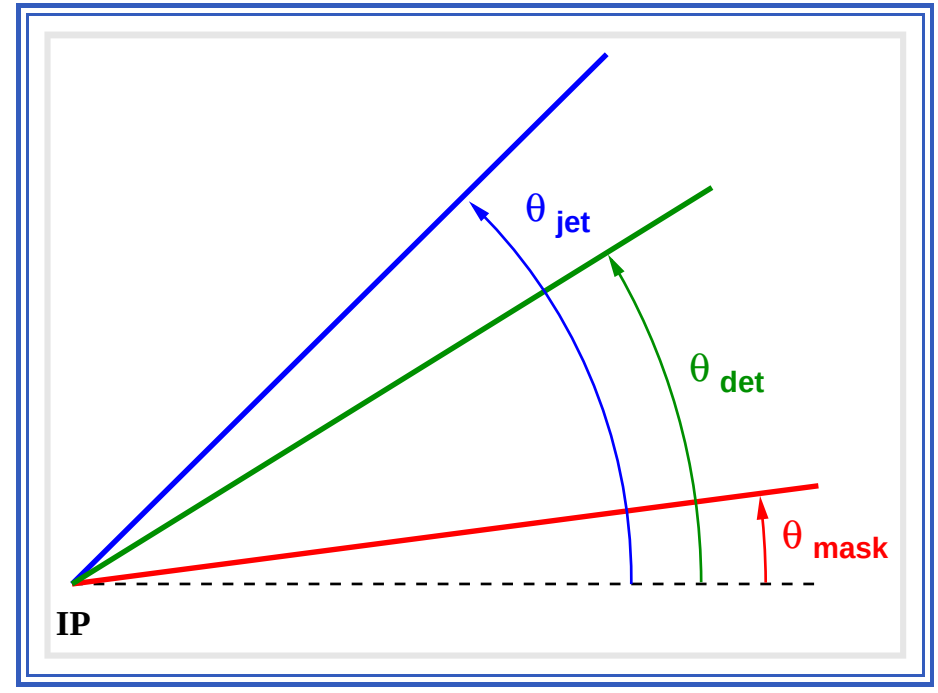
$\gamma\gamma \to$ *hadrons* events

Angular E_T-flow per bunch crossing.



Generation for $\sqrt{s_{ee}} = 210.5$ GeV.

Angular cuts



Detector mask

Particles on Pythia level: $\cos\theta_{\text{mask}} = 0.99$

OE suppression

Tracks & clusters: $\cos\theta_{\text{det}} = 0.85$

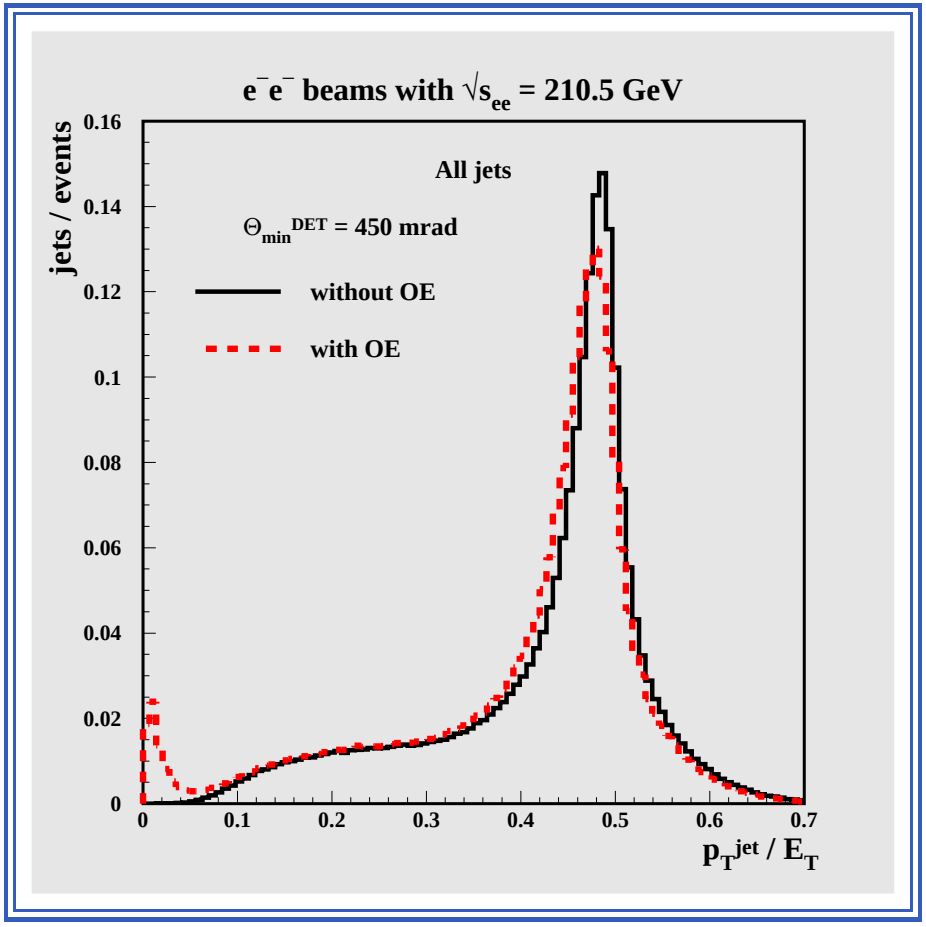
$\gamma\gamma \to Q\bar{Q}(g)$ suppression

Jets: $\cos\theta_{\text{jet}} = 0.71$ (0.65)

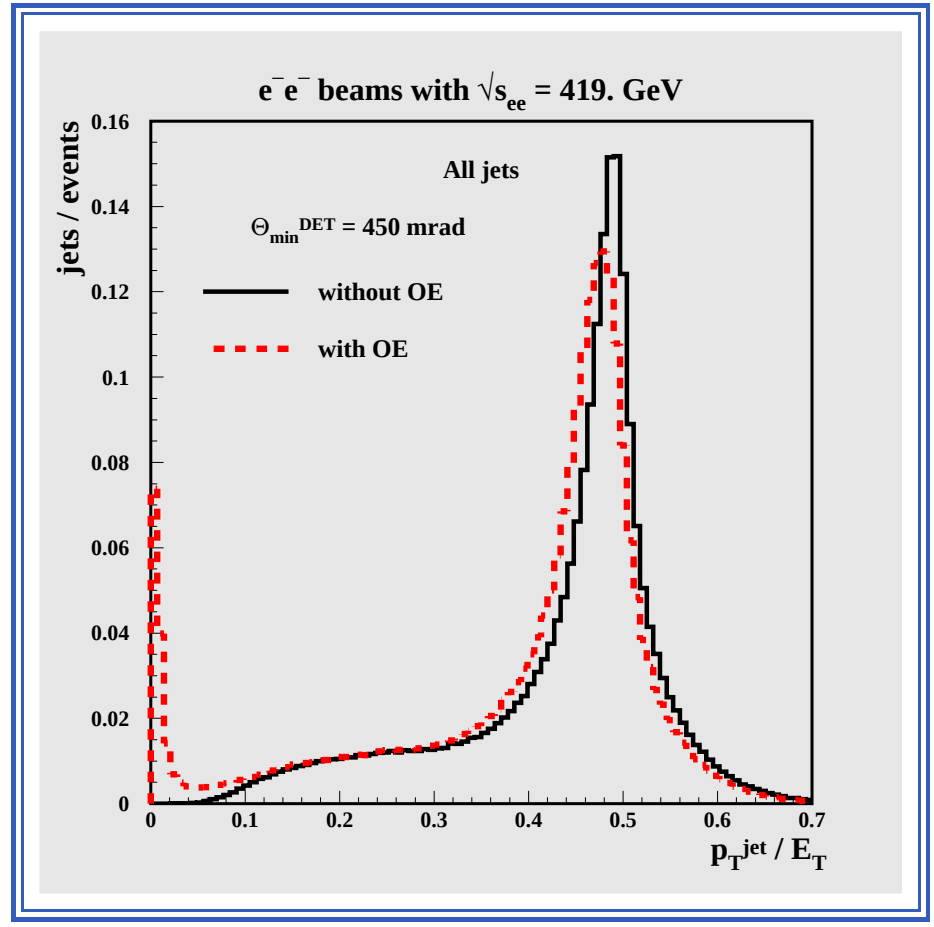
Transverse momenta of jets

Discriminating between gluon-jets (PS) & OE

SM - signal only



MSSM - signal only



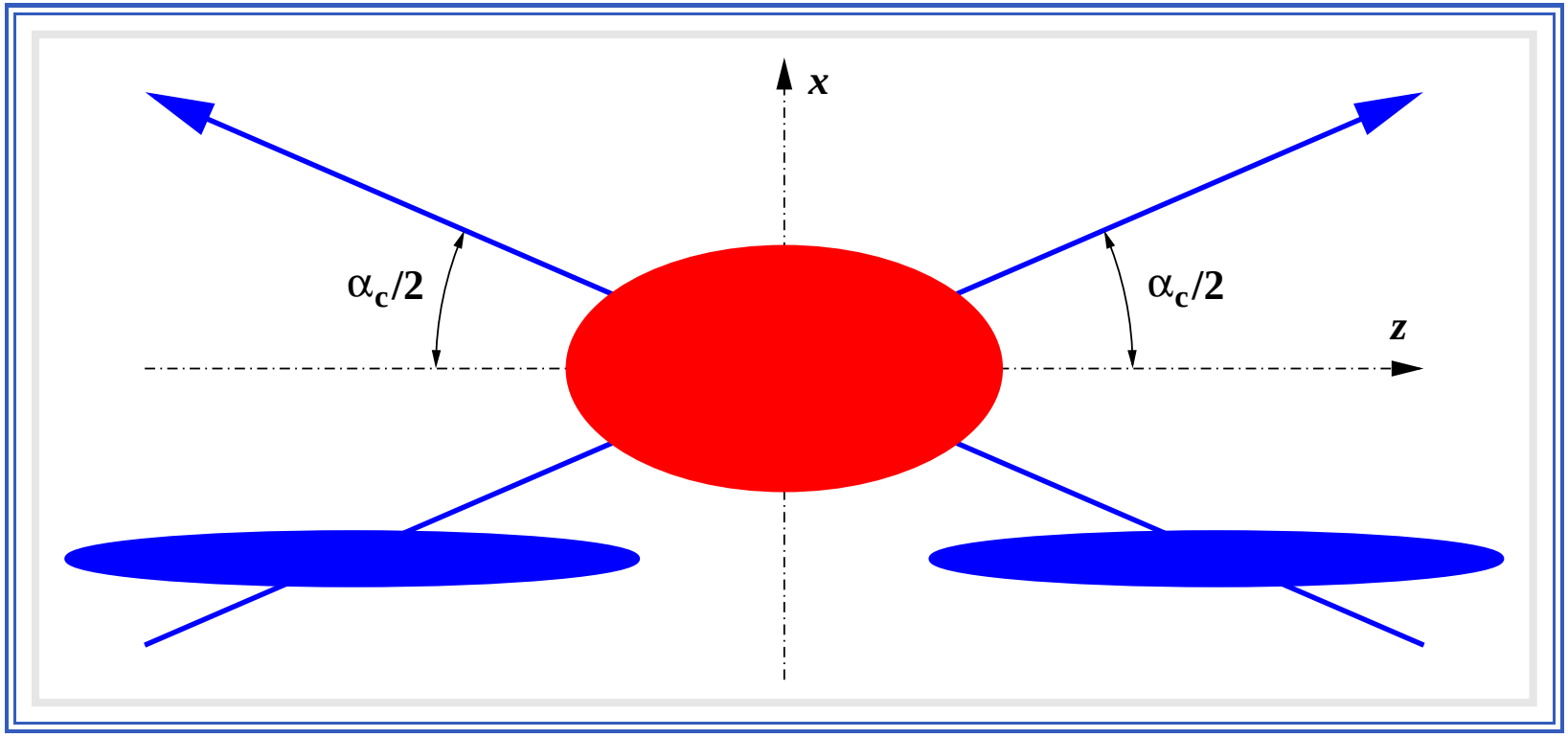
Contribution of OE $\Rightarrow$ additional cut: $p_T^{\rm jet}/E_T > 0.1$ for each jet

Crab-wise crossing of beams

$$\sigma'_x = \sqrt{\tfrac{1}{2}(\sigma_x^2 + \sigma_z^2 \tan^2(\alpha_c/2))} \qquad \sigma'_y = \sigma_y/\sqrt{2} \qquad \sigma'_z = \sigma_z/\sqrt{2}$$

Bunch: $\sigma_x = 140$ nm $\sigma_y = 15$ nm $\sigma_z = 0.3$ mm

Primary vertex: $\sigma'_x = 3.6\ \mu$m $\sigma'_y = 11$ nm $\sigma'_z = 0.2$ mm



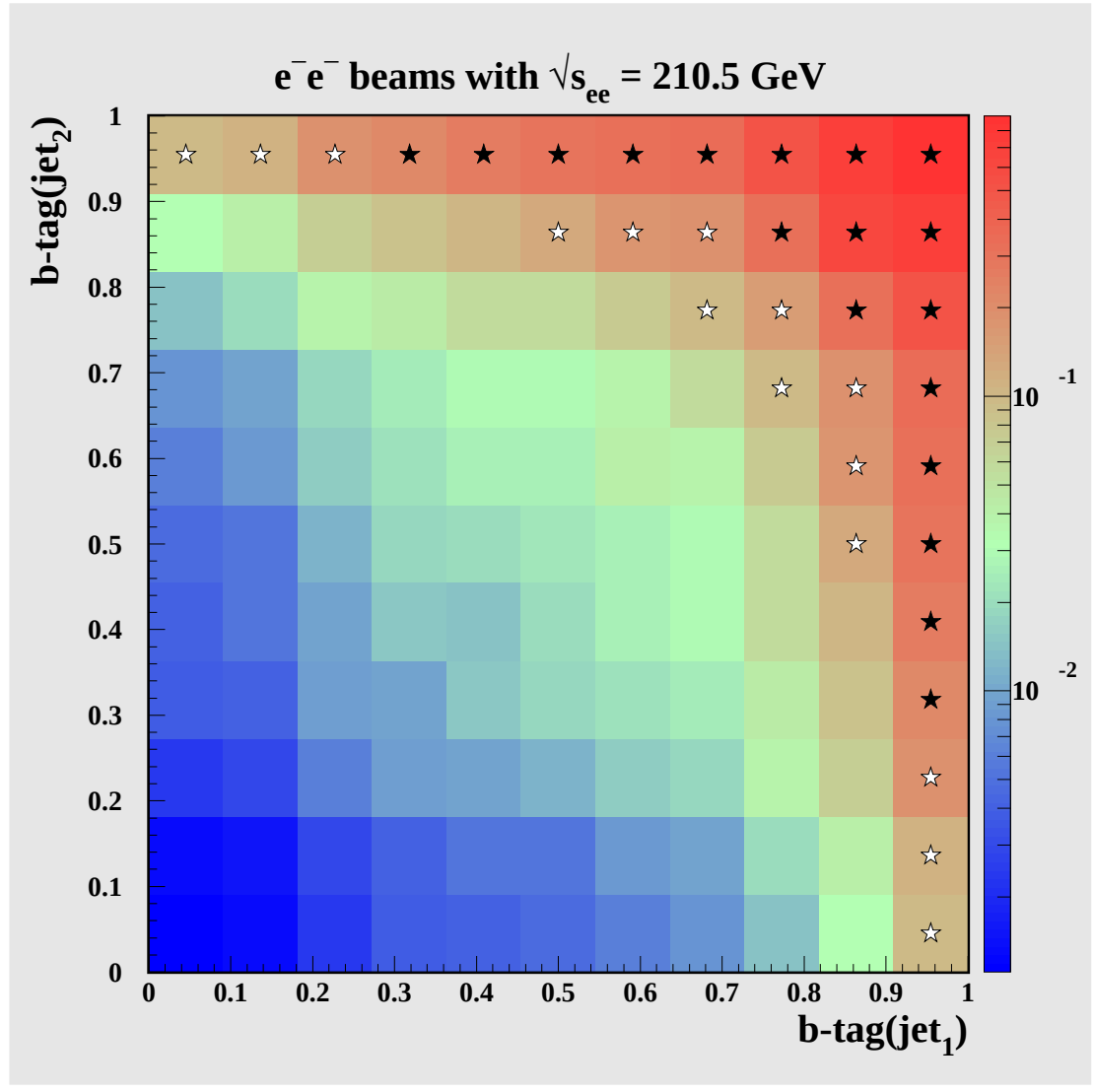
$\alpha_c = 34$ mrad

higgs-tagging at $M_h = 120$ GeV

higgs-tagging: a cut on the ratio
of $\gamma\gamma \to h \to b\bar{b}$
to $\gamma\gamma \to b\bar{b}(g)$, $c\bar{c}(g)$ events
$\Rightarrow \varepsilon_{higgs} = 70$ %
$\varepsilon_{bb} = 66\%$, $\varepsilon_{cc} = 4\%$

Earlier we used b-tagging:
a cut on the ratio
of $\gamma\gamma \to b\bar{b}(g)$
to $\gamma\gamma \to c\bar{c}(g)$ events
$\Rightarrow \varepsilon_{higgs} = 85$ %
$\varepsilon_{bb} = 82\%$, $\varepsilon_{cc} = 2\%$

Tighter cuts are needed
due to OE contribution



Black stars – optimized selection
Black+white stars – analysis without OE

SM, $M_h = 120$ GeV

Corrected reconstructed mass: $W_{\rm corr} \equiv \sqrt{W_{rec}^2 + 2P_T(E + P_T)}$

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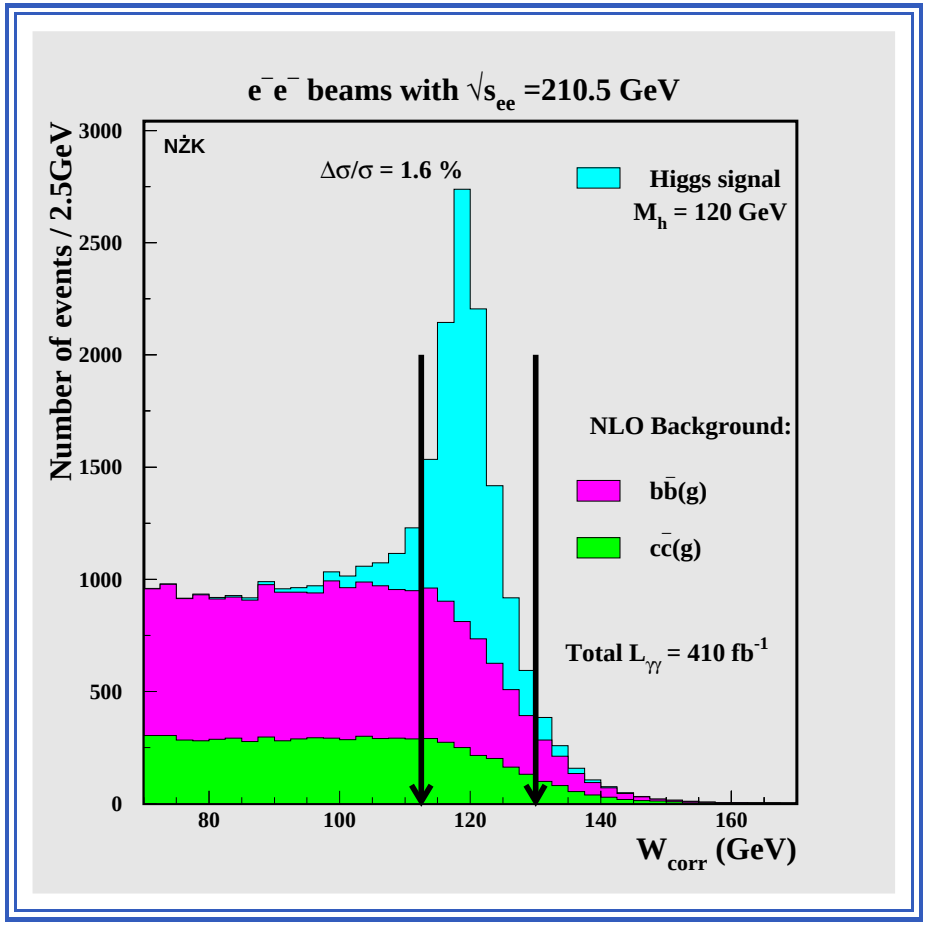
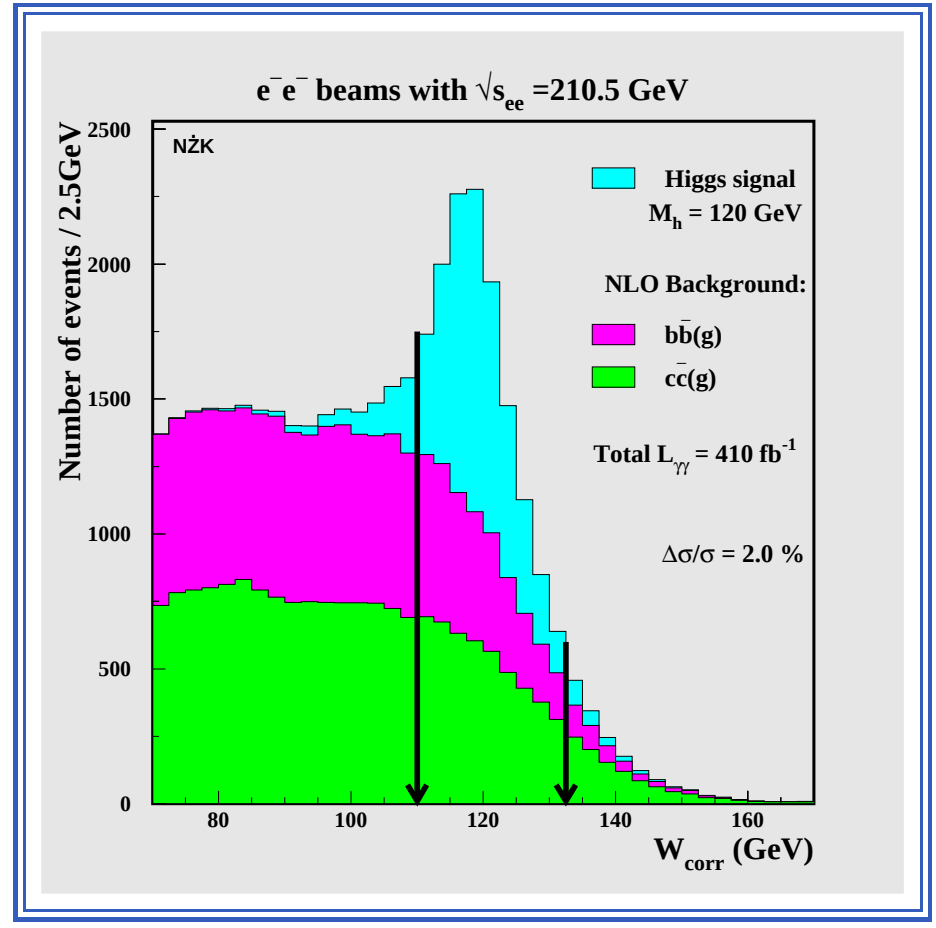
OLD



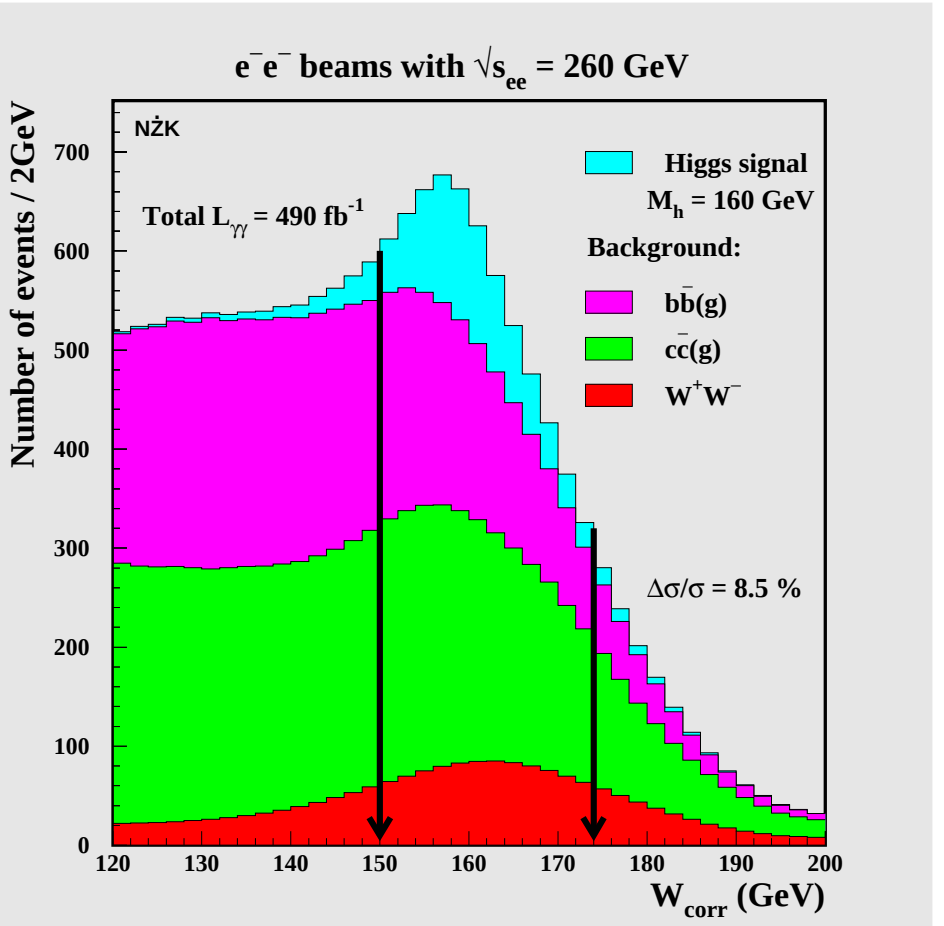
NEW



1.6% → 2%

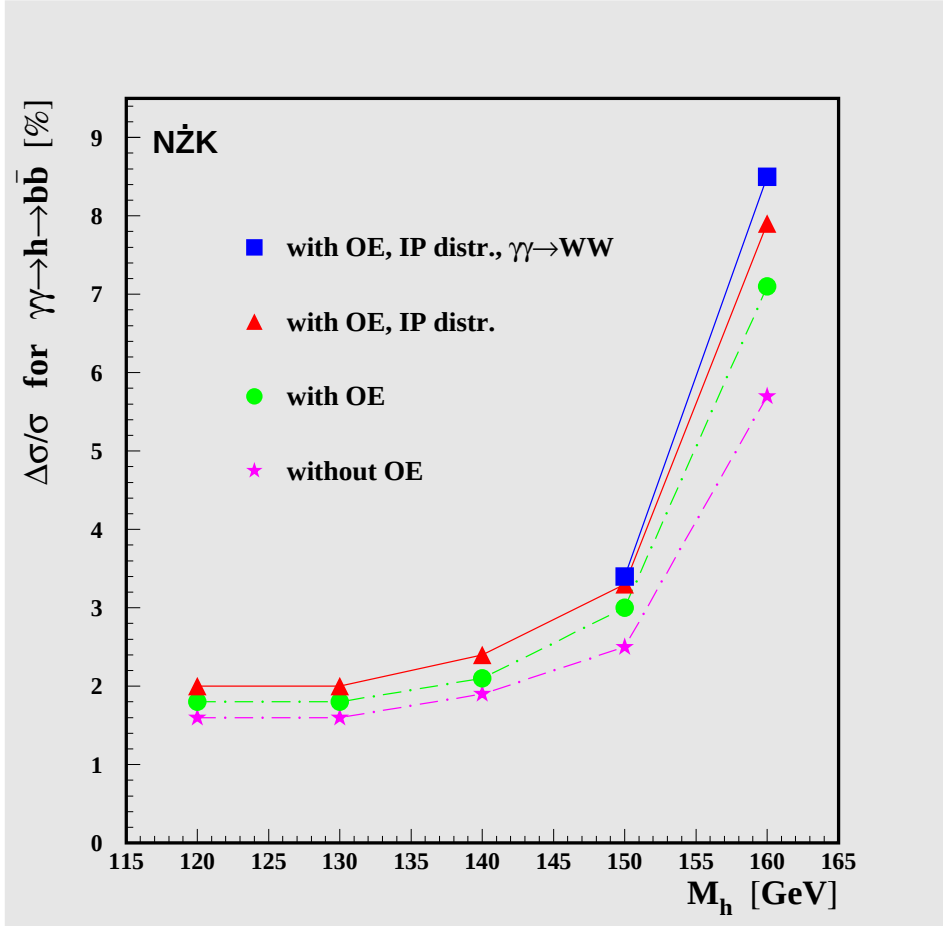
SM, $M_h = 120$-160 GeV

NEW: $\gamma\gamma \to W^+W^-$ background



$M_h = 160$ GeV

Precision of $\gamma\gamma \to h \to b\bar{b}$ measurement

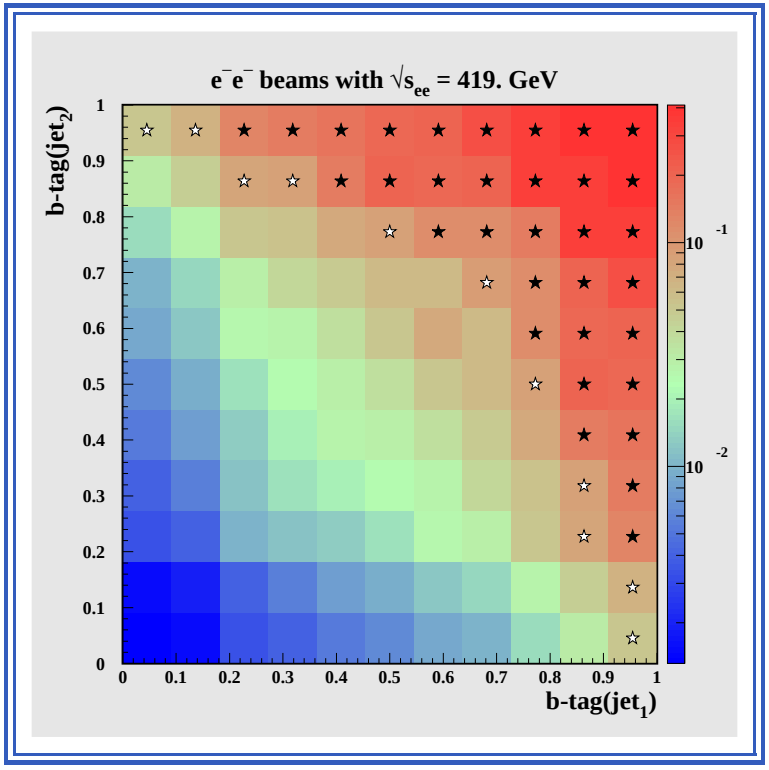


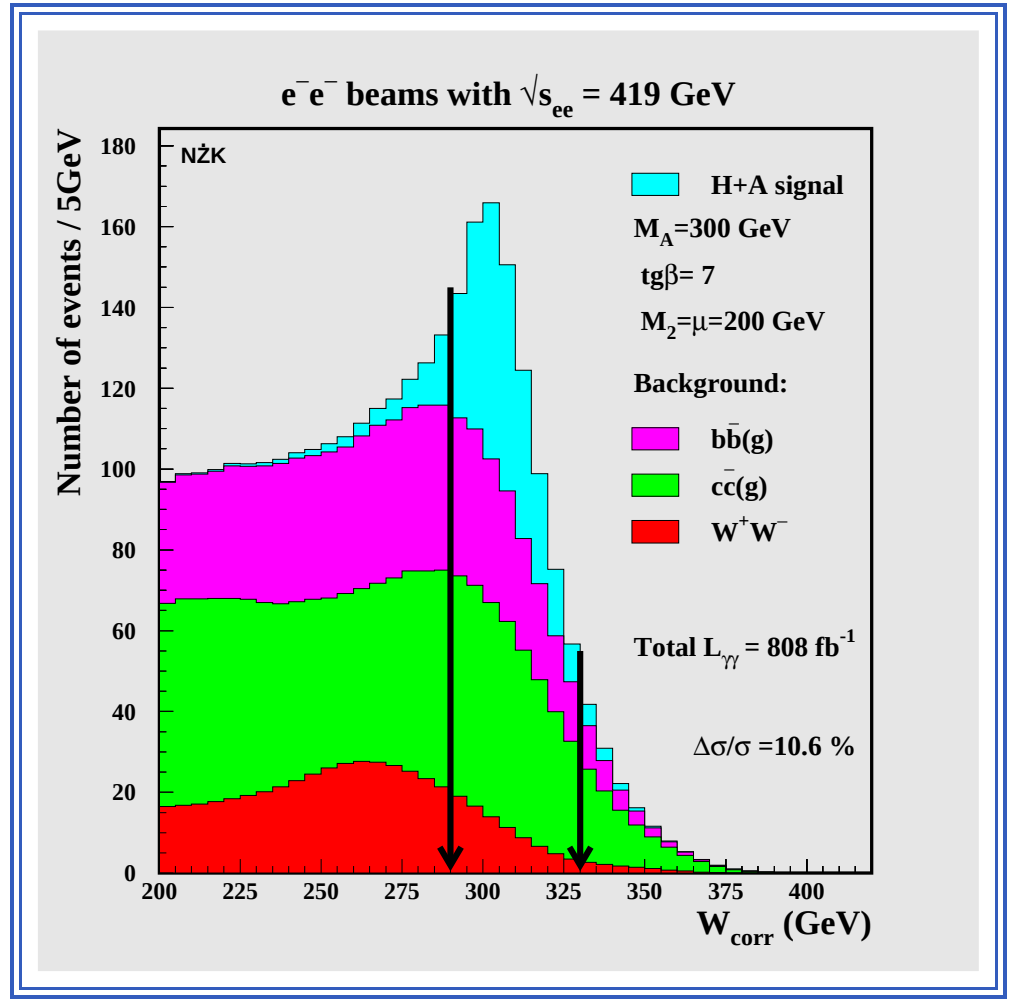
MSSM, $M_A = 300$ GeV

NEW

Number of overlaying events: ~ 2 per bc

Optimal *higgs*-tagging

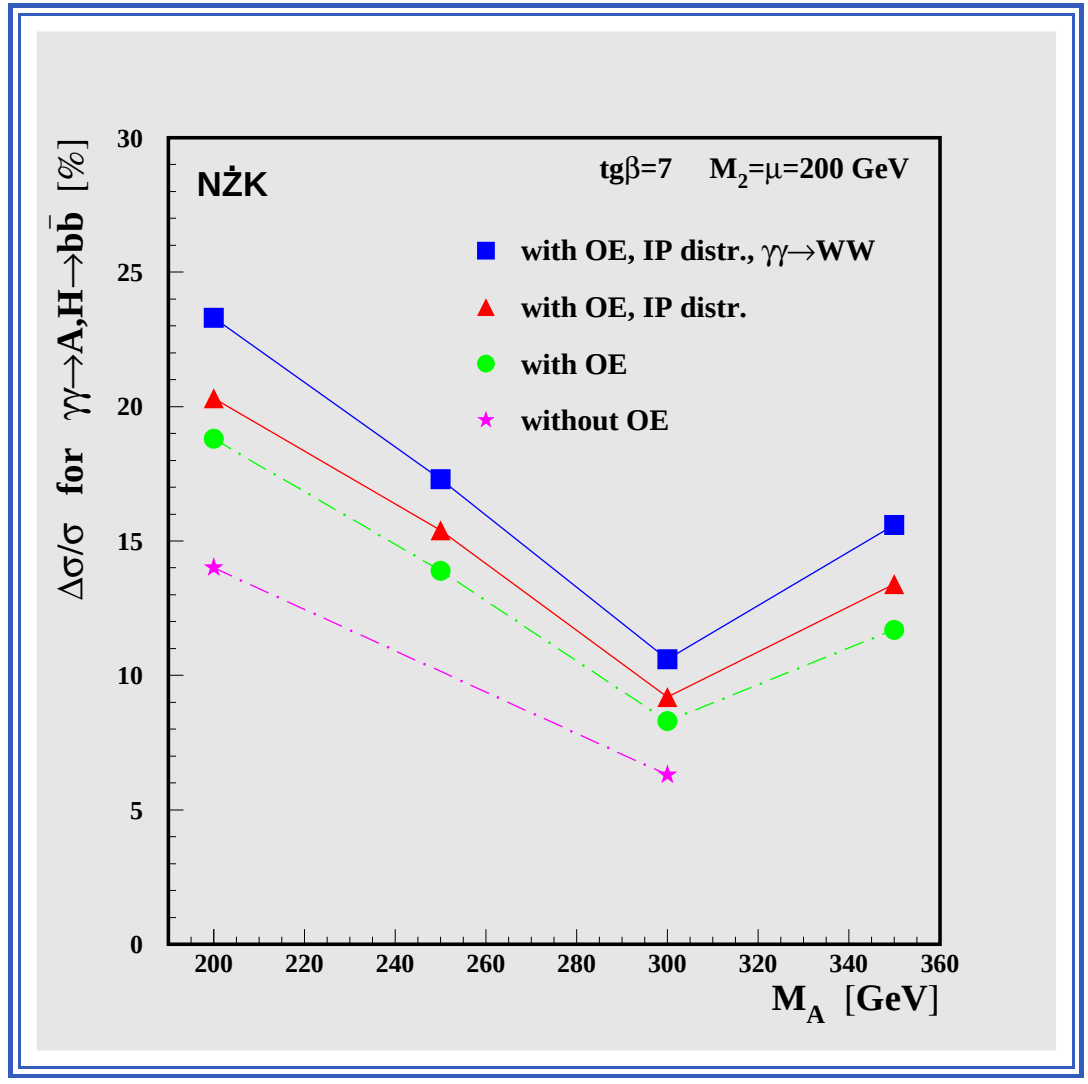




$$\frac{\#\gamma\gamma \to h \to b\bar{b}}{\#\gamma\gamma \to b\bar{b}(g),\ c\bar{c}(g)}$$

$$\varepsilon_{higgs} = 68\ \%$$

MSSM, $M_A = 200$-350 GeV



Precision between 11% and 23%.

Conclusions

NEW analyses for SM and MSSM:

- High precision for measurement of SM & MSSM higgses
  despite $\gamma\gamma \to$ *hadrons* pile-up events and primary vertex distribution
- Cut on p_T^{jet}/E_T improves rejection of OE jets
- *higgs*-tagging: cut on the ratio of $\gamma\gamma \to h \to b\bar{b}$ to $\gamma\gamma \to b\bar{b}(g)$, $c\bar{c}(g)$ events
  $\Rightarrow$ improved $\gamma\gamma \to Q\bar{Q}(g)$ background suppression
- Precision of 2% for $\Gamma(h \to \gamma\gamma)\mathrm{Br}(h \to b\bar{b})$ at $M_h = 120$ GeV
- Precision between 11% and 23% for $M_A = 200$–350 GeV.
- Inclusion of $\gamma\gamma \to W^+W^-$ background influences precision estimates
  for MSSM case. Improvement in discriminating of W^+W^- possible

Plans:

- MSSM: parameters space scan